LIFE INDEX AIR

PROJECT FUNDED BY EUROPEAN UNION

Exposure Modelling Setup

Deliverable D-B3.2

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CONTENTS

1. EXECUTIVE SUMMARY

The present deliverable describes the exposure modelling setup designed to accomplish the goals of action B3. The main objective of action B3 is to determine the exposure of the target population (children) to the selected pollutants using a modelling approach.

The report presents the exposure modelling methodology and its setup for the application to the different Index-Air case studies.

2. INTRODUCTION

Every day, a person breathing is exposed to different concentrations of atmospheric pollutants, as he/she moves from and to different outdoor and indoor places. Particulate matter, coarse and fine, is one of the pollutants of most concern in terms of adverse health effects [EEA, 2017]. Air pollution problems related to particulate matter are more frequent and severe at urban areas, with high population density, and where industrial and traffic particulate matter emissions are the major contributor to air pollution.

Exposure studies can be carried out to obtain estimates of the exposure of the individual (personal exposure) or for a larger population group (population exposure). The exposure can be obtained from direct measurements on individuals or can be determined from model calculations [Hertel et al., 2001]. The general approach for exposure estimation considers exposure as the event occurring when an individual occupies a place, during a certain period, where air pollutant concentrations are not null, called microenvironment, and can be expressed by:

$$Exp_i = \sum_{j=1}^{n} C_j t_{i,j} \qquad \text{(Equation 1)}$$

where Exp_i is the total exposure for person i over the specified period of time; C_j is the pollutant concentration in each microenvironment j and $t_{i,j}$ is the time spent by the person i in microenvironment j.

The inhaled dose, that refers to the concentration of pollutant that enters the human body by inhalation, is estimated by:

$$Dose_i = C_j \cdot t_{i,j} \cdot V_{i,j} \qquad \text{(Equation 2)}$$

where V_{ij} is the ventilation rate of child i in microenvironment j.

To model human exposure, over a selected region, by a numerical approach, three types of input data are needed: the population/individuals characterization (number of people and daily time-activity pattern), the spatial distribution of the microenvironments visited by the population/individual and the temporal variation of concentrations in each microenvironment [Borrego et al., 2008]. This approach can either be used for population exposure or individual exposure estimation and is the basis for the modelling setup and application of LIFE Index-Air project under Action B3. This action comprises the compilation of emission data, preparation of meteorological inputs, air quality model setup, that were reported in deliverable D-B3.1, and the preparation of exposure models which is the focus of the current report.

3. DESCRIPTION OF THE MODELLING SETUP

Under Action B3, air quality and human exposure numerical modelling are used to determine both individual and population exposure: first a meteorological model is applied to obtain meteorological data, which together with emission data, will drive the air quality/dispersion simulations which, in turn, will produce the pollutants concentration patterns that, combined with measurements, will allow determining human exposure by the application of an exposure model that includes two modules to estimate population and individual exposure respectively. Based on the objectives and tasks of Action B3, the general methodology was defined and is presented in Figure 1.

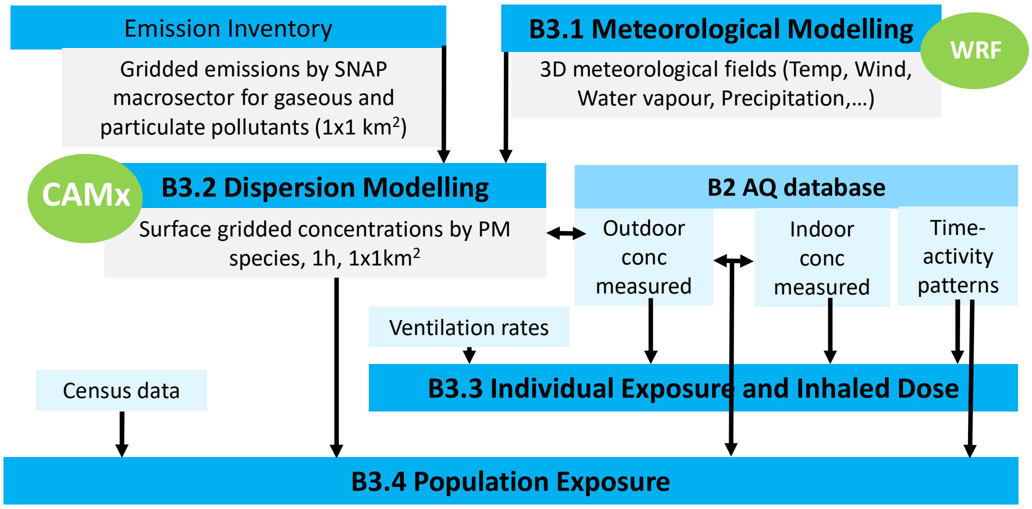

Figure 1. Methodological approach of Action B3 including air quality, population exposure and individual exposure modelling.

The following sub-sections are devoted to the exposure modelling setup and input data needed for the population exposure and individual exposure estimation.

3.1. POPULATION EXPOSURE MODELLING

The population exposure module to be used in this project permits the estimation of the population exposure to air pollutants on an hourly basis for a defined gridded domain, based on the target population distribution, time-activity patterns, microenvironments spatial distribution and pollutant concentrations at microenvironments.

Population census data will be used to get the spatial distribution of children in each study area. Time-activity patterns from task B2.1 will be used to characterize the daily routine of children populations over the study areas. Also a detailed spatial characterization of microenvironment types will be performed, on a gridded basis for each study area. It will serve as input for the model to extrapolate the indoor concentrations of each microenvironment for the whole areas of interest, based on the spatial and temporal distribution of air pollutant concentrations simulated by WRF-CAMx modelling system under task B3.3 for the study areas at 1h time resolution and 1x1 km^2 spatial resolution, combined with indoor/outdoor ratios from task B2. Figure 2 presents the general methodology for population exposure estimation.

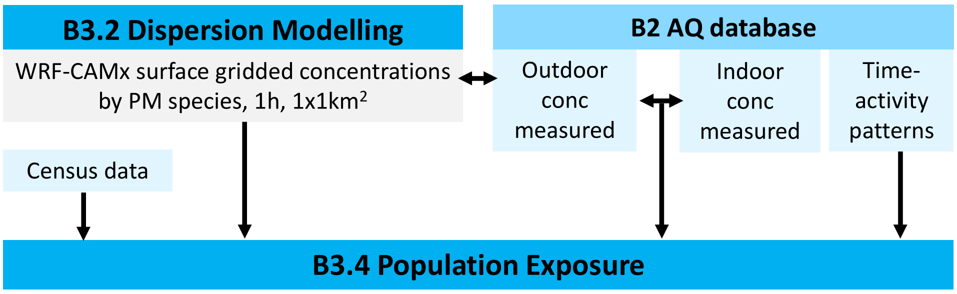

Figure 2. Methodological scheme and input data for the population exposure estimation.

Input data for each case study is much dependent on the availability of air quality data in the database that is being built in action B2, in particular on indoor air quality data, and also on additional available information that can be provided for each case. This required information includes population distribution, land use data with different urban land uses to help on the definition and distribution of microenvironments (homes, offices, schools …).

The exposure model calculates the indoor concentrations using the outdoor concentrations simulated by the WRF-CAMx modelling system and indoor/outdoor relations. In the absence of specific data on indoor/outdoor air quality measurements to derive In-Out ratios for each microenvironment, data from literature will be used, as the ones given in Table 1 [Gulliver and Briggs, 2004; USEPA, 1997].

Table 1 - Indoor-Outdoor relations for PM10.

Home	Other indoors	In vehicle
$C_{it}(day) = 48 + 0{,}51C_{out}$ $C_{in}(night) = 20 + 0{,}52C_{out}$	$C_{in}(day) = 48 \cdot (1 - 0.14) + 0{,}51C_{out}$ $C_{int}(night) = 20 \cdot (1 - 0.14) + 0{,}52C_{out}$	$C_{vehicle} = 13{,}1 + 0{,}83C_{out}$

For the Lisbon case study, indoor and outdoor air quality data acquired in the field campaign performed under action B2 will be considered and complemented by information on population statistics from Census 2011 and on land use data from COS database (Portuguese land use at high resolution). Examples of these databases are shown in Figures 3 and 4.

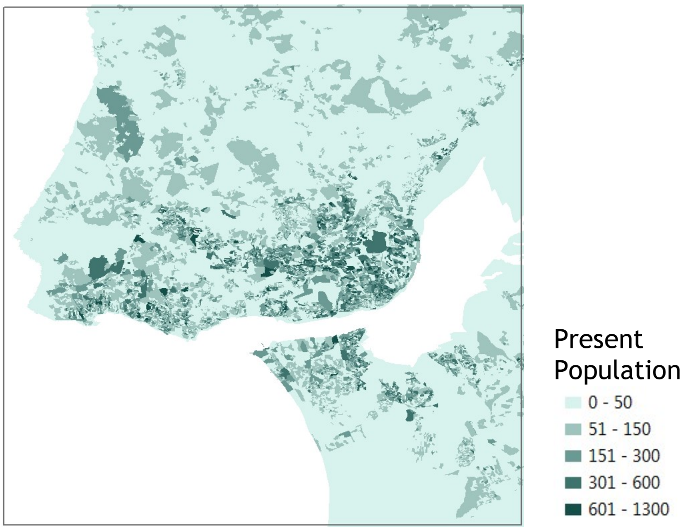

Figure 3. Distribution of the population present (number of individuals) in each subsection of the Lisbon modelling domain.

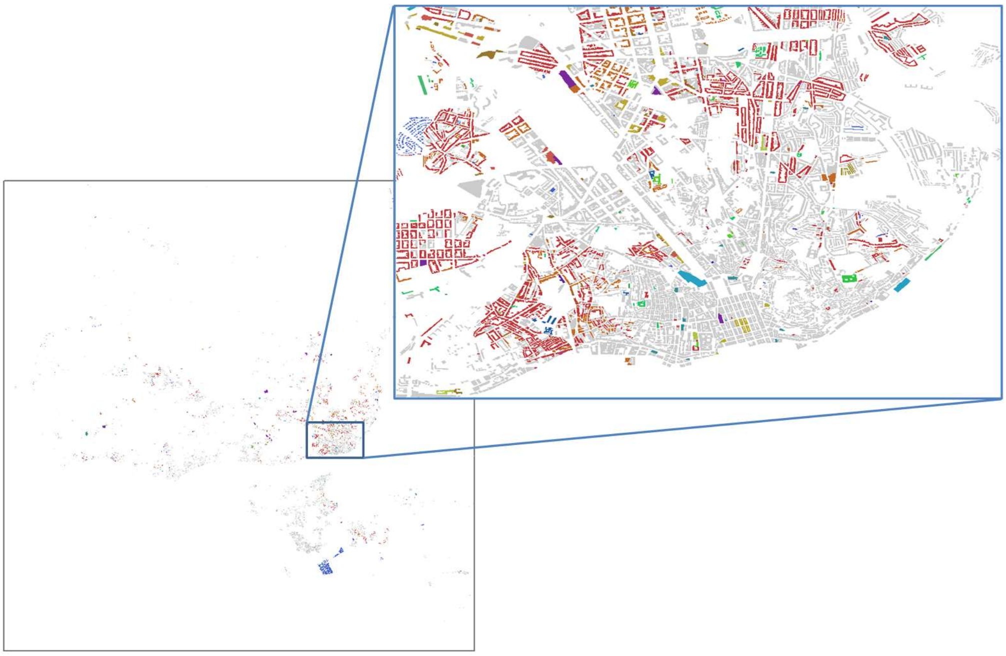

Figure 4. Buildings distribution in the Lisbon modelling domain.

Thus, knowing the number of children per hour in each grid cell of the study area (based on time activity patterns and population census), knowing the different microenvironments in the study area per grid cell and their hourly indoor air quality (based on measured indoor values, on outdoor simulated values and on in-out ratios), and knowing the hourly spatial distribution of outdoor air quality (provided by the WRF-CAMx modelling system), will allow the estimation of the children population exposure to air pollutants, in particular PM. The hourly data will allow the calculation of other interesting time averaged values.

3.2. INDIVIDUAL EXPOSURE MODELLING

Individual exposure is provided for single individuals as they represent some population subgroups. Different methodologies could be applied for this purpose. In the absence of direct measurements, estimations based on exposure concentration data and the time of exposure, are considered. Under Index-Air, similarly to the population exposure, the individual exposure and the inhaled dose are estimated using the microenvironment approach and calculated according to Equations 1 and 2. The methodological approach is presented in Figure 5.

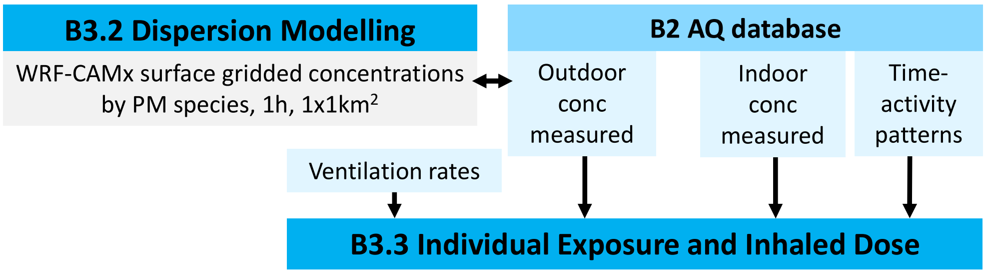

Figure 5. Methodological scheme and input data for the individual exposure estimation.

The estimation of individual exposure and inhaled dose will be based on the microenvironment approach that considers exposure as the event occurring when an individual occupies a place, during a certain period, where air pollutant concentrations are not null, called microenvironment. Under this concept, two types of information are required to estimate human exposure – time-activity patterns and air pollutant concentrations.

For the Lisbon case, the individual exposure module will use as inputs the time-activity pattern of each studied children (from B1.1), and the concentrations of PM10, PM2.5 and chemical compounds measured at each microenvironment (indoor and outdoor) visited by the children along a day – home, school, transport (from tasks B1.2 and B1.3). When and where necessary, the outdoor microenvironments' concentrations can be inferred by the CAMx modelled concentrations.

4. CONCLUSIONS

This deliverable presents the methodology for human exposure estimation under action B3 of LIFE Index-Air Project. An exposure model will be adapted to be applied considered the input data available. The model includes a module for population exposure and a module for individual exposure and inhaled dose estimation. The modelling setup and input data required were described.

5. REFERENCES

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